Theory of Mind in Emerging Reading Comprehension: A Longitudinal Study of Early Indirect and Direct Effects

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Abstract

The relation between children's theory of mind (ToM) and emerging reading comprehension was investigated in a longitudinal study over 2.5 years. 80 children were tested for ToM, decoding, language skills and executive function (EF) at Time 1 (mean age = 3:10 years). At Time 2 (mean age = 6:03 years) children's word reading efficiency, language skills and reading comprehension were measured. Mediation analysis showed that ToM at Time 1, when children were around four years old, *indirectly* predicted Time 2 reading comprehension, when children were six years old, via language ability, after controlling for age, non-verbal ability, decoding, EF and earlier language ability. Importantly, ToM at four years old also *directly* predicted reading comprehension two and a half years later at six years. This is the first longitudinal study to show a direct contribution of theory of mind to reading comprehension in typical development. Findings are discussed in terms of the Simple View of Reading (SVR); ToM not only supports reading comprehension indirectly by facilitating language, but also directly contributes to it over and above the SVR. The potential role of metacognition is considered when accounting for the direct contribution of early ToM to later reading comprehension.

Key words: Theory of Mind; Reading Comprehension; Simple View of Reading; Metacognition; Longitudinal

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Theory of mind in emerging reading comprehension: a longitudinal study of early indirect and direct effects

The Simple View of Reading (SVR; Gough & Tunmer, 1986; Hoover & Gough, 1990) proposes that reading comprehension is the product of two key dimensions: word reading (decoding) skills and linguistic comprehension. Though empirical evidence has shown that decoding ability and linguistic comprehension skills account for a large percentage of variance in reading comprehension (e.g., Adlof, Catts, & Little, 2006; Johnston & Kirby, 2006; Kendeou, van den Broek, White & Lynch, 2009; Vellutino, Tunmer, Jaccard, & Chen, 2007), researchers have argued that the SVR may be *too* simple (e.g., Conners, 2009; Johnston & Kirby, 2006; Pressley et al., 2009) and that an additional component needs to be added to the model to account for variance unexplained by decoding and linguistic comprehension (Kirby & Savage, 2008). Potential candidates for this have included speed of processing, naming speed and executive function (EF) (e.g., Adlof et al., 2006; Johnson, Jenkins, & Jewell, 2005; Johnston & Kirby, 2006; Joshi & Aaron, 2000) as well as higher-order comprehension skills, such as inference making and comprehension monitoring (e.g., Cain, Oakhill, & Bryant, 2004; Kim, 2015; Oakhill & Cain, 2012). However, whilst these studies have shown that these factors contribute to reading comprehension performance it remains unclear whether their contribution is over and above the two dimensions of the SVR. The aim of the present study was to consider the role of theory of mind as a potential further factor facilitating emerging reading comprehension.

Children's developing attentional control has also been considered as a potential third component of the SVR. Conners (2009) reported that attentional control (the ability to inhibit irrelevant responses and initiate alternative responses) accounts for variance in reading comprehension even after controlling for decoding, language comprehension, processing speed and verbal short-term memory. Conners (2009) argued that attentional control might contribute to reading comprehension through its role in the higher-order comprehension process of detecting and repairing comprehension failures. Importantly though, other researchers propose that this type of strategy, along with locating information, finding main ideas, determining text structure and using visual cues are essentially *metacognitive processes* (Kirby & Savage, 2008). Metacognitive processes require thinking about aspects of one's thinking, which may draw on EF abilities, but go beyond them. Specifically, Kirby and Savage (2008) suggest that these strategies are especially relevant to reading comprehension, due to the text remaining visible to the reader. They argue that the SVR does not address the role of these metacognitive strategies in reading comprehension.

Metacognition relates to higher-order thinking, involving not only dynamic control over active cognitive processes, but also reflective insight about these processes (Kuhn, 2000). One well-researched measure of metacognition in young children is their theory-of-mind ability (Courtin & Melot, 2005; Flavell, Green, & Flavell, 2000). Theory of mind (ToM) broadly involves the ability to impute mental states such as beliefs, desires and intentions to oneself and to others in order to explain and predict behaviour (Premack & Woodruff, 1978; see Doherty, 2008 for overview). A crucial milestone in this development occurs when children gain an understanding that someone can hold a mistaken (false) belief about the world. This ability occurs around four years of age (Wellman, Cross, & Watson, 2001) and is shown by children's performance in explicit false belief tasks (Wimmer & Perner, 1983). A standard false belief task typically involves a character (e.g., Sally) leaving an object (e.g., a ball) in one location and, whilst away, another character (e.g., Anne) unexpectedly moving the object to a new location. When Sally returns the child is asked a direct question "Where will Sally look for her ball first?" A child that has a mature ToM will understand that Sally will go to the location where she left the ball (because they understand this is where she thinks it is), rather than the second location (where they know the ball actually is). Passing these tasks clearly shows that children can now *think* (represent) how someone *thinks about* (represents) something and can therefore understand different perspectives (Perner, 1991; Perner, Stummer, Sprung, & Doherty, 2002). This ability is clearly metacognitive in nature as it involves being able to think about thinking (Flavell et al., 2000).

Theory of mind and reading comprehension

By the time children begin to read at around five years old they will typically have acquired an understanding that mental states and perspectives may differ from reality and thus are able to begin to understand that stories may include intended meanings that may not represent the child's own perspective and knowledge (Lecce, Zocchi, Pagnin, Palladino, & Taumoepeau, 2010; Woolley, & Cox, 2007). They are able to apply understanding and reasoning about the minds of others to begin to interpret the thoughts and actions of story characters (Emery, 1996). In support of this, Pelletier and Astington (2004) investigated the relation between the developing ToM abilities of four and five year olds and their understanding of characters' actions and consciousness in spoken story narratives. They found that children's ability to understand stories followed a similar developmental pathway as ToM. More specifically, children with an advanced ToM (as shown by their performance on ToM tasks and also their use of mental state terms such as "think" and "know") were more likely to have a coherent understanding of the story (over and above their general language ability). Pelletier and Astington (2004) suggested that children's ability to understand and coordinate action and consciousness within a narrative is therefore clearly linked with their ToM.

To date, the two studies that have examined ToM and reading comprehension in typically developing children have found no clear evidence of a direct link (Guajardo & Cartwright, 2016; Kim, 2015). However there were indirect effects. In a cross-sectional study of 145 South Korean six-year-old children, Kim (2015) showed that ToM, predominantly measured with first-order false belief tasks, was indirectly linked to concurrent reading comprehension via listening comprehension. In other words, children's developing ToM facilitated their language ability, which in turn contributed to their reading comprehension. Likewise, Guajardo and Cartwright (2016) found that false belief understanding uniquely predicted concurrent oral language comprehension in their sample of 31 children aged between three and five years. Longitudinally, Guajardo and Cartwright (2016) went on to show that the children's early language comprehension predicted later reading comprehension at six to nine years old, suggesting that early false belief understanding indirectly contributed to later reading comprehension via language comprehension. These findings are consistent with previous evidence that has shown that ToM predicts language development (Milligan, Astington, & Dack, 2007; Slade &

Ruffman, 2005). In this respect, children's developing social cognition affects their emerging reading comprehension, but does so indirectly by facilitating the language skills needed to engage in reading comprehension.

However, there is some evidence for a direct link between ToM and reading comprehension. In a study of adolescents with autism spectrum disorders (ASD) Ricketts, Jones, Happé, and Charman (2013) found that ToM ability, using broader, advanced measures of ToM, uniquely predicted reading comprehension over and above word reading ability and oral language skills. This suggests a direct contribution from ToM to reading comprehension in an atypical population with poor social understanding (Ricketts et al. 2013). It is plausible that similar direct effects are also present in typical development, but previous studies, which have included older children (Kim, 2015), or a very small sample with a broad age range (Guajardo & Cartwright, 2016) have missed early, potentially crucial, developmental effects (Lecce, Caputi & Hughes, 2011). The current longitudinal study aims to address these issues by investigating the direct and indirect effects of the early ToM abilities of a large sample of young children (mean age 3:10 months) on their later emerging reading comprehension at six years.

Theory of mind might directly facilitate later reading comprehension not only through promoting the ability to think and reason about story characters and their actions, but also other abilities that impact on general comprehension skills. Successful reading comprehension requires metacognitive processes such as monitoring one's own knowledge (self-monitoring) whilst reading, and responding to and adjusting to (repairing) other information that may be non-social or non-fictional in nature (Kirby & Savage, 2008; Oakhill & Cain, 2012). In other words, text may also represent and inform knowledge, actions and understandings, not necessarily to do with story characters or oneself as a reader. Importantly, ToM, as measured by false belief understanding, has also been linked to other aspects of metacognition beyond social understanding, for example, it is linked to knowledge about memory and what makes remembering easier or more difficult, i.e., meta-memory (Lecce, Bianco, Demicheli, & Cavallini, 2014; Lockl & Schneider, 2007), to understanding that objects can have multiple names or labels, i.e., metalinguistic ability (Perner et al., 2002) and also to children's understanding about the source of their knowledge (Bright-Paul, Jarrold, & Wright, 2008). It is unclear whether this link is due to ToM being a socially specialized ability that leads to or facilitates these more general or non-social metacognitive abilities (Lockl & Schneider, 2007; Ricketts et al., 2013) or whether ToM draws on the same underlying ability as these other aspects of metacognition (Iao, Leekam, Perner, & McConachie, 2011; Perner, 1991). Either way, ToM might therefore be expected to be directly linked to reading comprehension not only because of the social aspect of reading comprehension (i.e., understanding story character intentions, actions and behaviours), but also because of its links to other aspects of metacognition which may facilitate or contribute to the metacognitive requirements of reading comprehension more generally.

To fully consider the degree to which ToM may predict reading comprehension, it was also essential to control for shared abilities in language and executive function (EF). ToM draws heavily on language skills (Slade & Ruffman, 2005; see Milligan, Astington, & Dack, 2007 for meta-analysis). As such, examining the unique effects of ToM over and above the linguistic comprehension dimension, controls for the potential shared variance between ToM and reading comprehension. Children's EF ability also increases rapidly between the ages of three and four years, and is strongly linked to ToM development (Carlson & Moses, 2001; Shahaeian, Henry, Razmjoee, Teymoori, & Wang, 2015; see Devine & Hughes, 2014 for meta-analysis). EF, particularly working memory, is also important for reading comprehension, not only through its contribution to higher-order comprehension skills (Cain et al., 2004; Sesma, Mahone, Levine, Eason, & Cutting, 2009), but also through its contribution to emergent code-related skills (Blair & Razza, 2007; see Allan, Hume, Allan, Farrington, & Lonigan, 2014 for meta-analysis). Given the importance for both ToM and reading comprehension, EF was controlled for, in addition to age, non-verbal ability (NVA), decoding and language skills, in the regression and mediation analyses.

The current study

The current longitudinal study followed a UK sample of 80 young children (mean age 3 years: 10 months) over two and half years to their emerging reading comprehension at six years old (mean age 6 years: 3 months). We aimed to investigate the contribution of children's theory of mind to their reading comprehension and whether its contribution would be over and above the decoding and linguistic components of the SVR. We did this in two analyses. Firstly, we looked at the extent that ToM, measured as false belief understanding, at around four years (Time 1) predicted reading comprehension at six years (Time 2), after controlling for Time 1 concurrent measures of age, non-verbal ability (NVA), executive function (EF), decoding, and language skills. Secondly, we examined the direct and indirect effects of early ToM at four years (Time 1) on later reading comprehension at six years (Time 2), controlling for the Time 1 concurrent SVR dimensions of decoding and linguistic comprehension, as well as shared correlates of age, NVA, and EF at Time 1. We predicted that early ToM would have both direct (over and above T2 linguistic comprehension) and indirect effects (via T2 linguistic comprehension) on later reading comprehension.

Method

Participants

The sample at Time 1 comprised of 80 preschool children (41 boys; mean age = 3:10 years, *SD* = 3.7 months, age range: 3:05 - 4:06 years) attending the preschool year of two mainstream primary schools in South East England. The majority of the children came from well-educated families: 88% of parents had completed a higher education award. All children spoke English as their first language. Children attended school for five three-hour sessions per week. There was no formal literacy instruction given during this educational year; however, children experienced games to promote phonological awareness and were read to often. Formal literacy instruction was introduced the following year, when the children began full time compulsory education (Reception). At Time 2, the end of Year 1, all 80 children (mean age = 6:03 years, *SD* = 3.8 months, age range: 5:09 - 6:09 years) were available for re-testing. Eighteen additional children, who were tested at Time 1, were excluded from the study, because they had moved to alternative primary schools by Time 2. This resulted in an attrition rate of 18% from preschool to Year 1, which compares favourably to other similar longitudinal studies, which have reported attrition rates of over 26% (e.g., Hood, Conlon & Andrews, 2008). Analysis of key variables revealed that there were no significant differences between the performances of the children who remained at the participating schools compared to those children who left during the study.

Materials & Measures

Nonverbal ability

Children's non-verbal ability was assessed at Time 1 using the Block Design subtest of The Wechsler Preschool and Primary Scale of Intelligence – III (WPPSI-III) (Wechsler, 2002). The task required children to recreate a series of geometric patterns using 3-4 coloured blocks (10 items), followed by designs using 2-4 two-toned blocks. Standard administration was followed. Non-verbal ability (NVA) therefore consisted of a scaled score with a mean of 10 and standard deviation of 3. Split-half reliability for four year olds is reported as .87.

Decoding

At Time 1, children's letter knowledge was measured using the Alphabet Knowledge subtest of the Phonological Abilities Test (PAT; Muter, Hulme, & Snowling, 1997). Children were presented with each letter of the alphabet printed individually on a card, and asked to give the name or sound of that letter. Letter knowledge therefore consisted of the number of letters correctly identified out of 26.

At Time 2, the Test of Word Reading Efficiency (TOWRE; Torgesen, Wagner, & Rashotte, 1999) was used to measure children's word reading accuracy and fluency. The TOWRE is standardised for children from the age of six years and consists of two subtests involving word and non-word stimuli to provide measures of sight word reading efficiency and decoding efficiency, respectively. Data from the subtests were converted to age-appropriate standard scores, which were then combined to provide an overall reading efficiency standard score with a mean of 100 and standard deviation of 15. The reliability coefficient for the total word reading efficiency score for six year olds is reported as .98.

Linguistic Comprehension

Vocabulary. At Time 1 and Time 2, children's receptive vocabulary was assessed using the British Picture Vocabulary Scale: 2nd Edition (BPVS II; Dunn, Dunn, Whetton, & Burley, 1997). Raw scores were used, therefore the maximum score was 84 at Time 1 (7 sets) and 120 at Time 2 (10 sets). Cronbach's Alphas are reported as .96 for 3-4 year olds and .94 for six year olds.

Language skills. At Time 1, children's receptive and expressive language ability was measured through two subtests (linguistic concepts and recalling sentences in context) of the Clinical Evaluation of Language Fundamentals – Preschool Second Edition (CELF-Preschool; Wiig, Secord, & Semel, 1992). Raw scores were used, therefore the maximum scores were 20 for linguistic concepts (reported Cronbach's α = .85) and 52 for recalling sentences in context (Cronbach's α = 93).

At Time 2, children's narrative comprehension ability was assessed, using the method outlined by Paris and Paris (2003). Children were asked to tell the story from a wordless picture storybook ("Robot-Bot-Bot", Krahn, 1979. The book recounts a story about a family who buy a robot to help with the household chores. One of the children subsequently breaks the robot, which results in the robot behaving in an erratic manner causing several mishaps, until it is finally repaired by the father.

After the children had finished telling the story from the book, it was removed and children were asked to recall the story. Children's recall was recorded, transcribed and scored for content (six aspects of the narrative: characters, setting, initiating event, problem, solution, and ending) and awareness of story structure, giving a maximum score of 9. Following recall, the book was replaced in front of the child and the researcher asked a set of ten comprehension questions, turning to corresponding pages of the book before asking each question. Questions elicited explicit information (characters, setting, initiating event, problem, outcome resolution) and implicit information (feelings, causal inference, inference dialogue, prediction, overall theme). Children's responses were transcribed in full and marked using a scoring rubric that awarded 0 to 2 points for each question, giving a maximum score of 20 points. Two independent coders scored 25% of children's responses for recall and comprehension questions. Inter-rater agreement was very good for both recall (Cohen's Kappa ranged between .80 and .99) and comprehension (Cohen's Kappa ranged between .76 and .97). An overall narrative comprehension score was calculated by summing the recall and comprehension scores to give a maximum total of 29.

Linguistic comprehension composite scores were calculated for language ability at each time point with the aim of developing a richer measure of language comprehension, in line with the linguistic dimension of the SVR, than is provided by vocabulary measures alone. At T1, two subtests of the CELF were summed to form a language skills score. Standard scores for CELF and T1 BPVS were calculated and summed for an overall T1 linguistic composite score. At T2, standard scores were calculated for the narrative comprehension and T2 BPVS and summed to form a composite score.

Executive function

At Time 1, children's executive function (EF) was assessed using the Reverse Word Span task (Slade & Ruffman, 2005) and a card-sorting task, adapted from Kloo and Perner's (2003) Dimensional Card Sorting task. The reverse word span task required children to reverse sets of words that were orally presented by the researcher. The researcher explained that she would say two words, e.g., "*horse – sheep*", and the child would say them in a backwards order, e.g., "*sheep – horse*". Following two practice items, the test phase included three sets of two words and a further three sets of three words. Scoring awarded one point for correctly reversing two words, two points for reversing three words and a half point was given for reversing two words that were not adjacent. The maximum score was 9. The card-sorting task required children to switch their response following a change of game rules. Initially, children were asked to sort a set of 9 cards (3 x yellow horse, 3 x red fish and 3 x blue bird) based on the colour of the illustrations. The test phase required children to sort an identical set of cards, but with a shift from their colour-based response to an animal-based response. One point was scored for each card correctly sorted in the 'animal' condition giving a maximum score of 9. Scores for both tasks were standardized and summed to give an overall T1 EF composite score.

Theory of Mind

At Time 1, children were administered two first-order false belief tasks. One was an *unexpected contents task* (Hogrefe, Wimmer, & Perner, 1986), where children were introduced to a toy character, which then remained out of sight while the child was asked to guess the contents of a "Smarties" tube. After the child had correctly guessed, they were shown that the tube, unexpectedly, contained colouring pencils. The box was then closed and the child was asked again what was inside (control question). The control question had to be answered correctly for credit to be given for the test questions. The child was then asked the first test question, which required them to say what they had thought was in the tube when they first saw it. The toy character was re-introduced and the child was reminded that the character had not seen the contents of the tube. The second test question required the child to say what the toy character would think was in the tube. Children were awarded one point for each correct answer, and a further point for justifying their answer to the second test question, if they had answered correctly, to give a maximum score of 3. Two independent coders scored 25% of children's responses. Agreement between the coders was excellent (Cohen's Kappa = 1.00). Scores were adjusted to reflect children's response to the control question and the adjusted scores were used in the analyses.

The *unexpected location task* (Wimmer & Perner, 1983) required the child to watch a story, demonstrated by the researcher with toy figures, where one character (Sally) played with a ball and then placed it inside a blue box. Sally then left the scene and a second figure (Anne) came to play. Anne found the ball, played with it and then placed it in the red box. Anne leaves the scene and Sally returned wanting to play with ball again. On Sally's return, the child was asked the test question, which requires the child to state where Sally will look for the ball and two control questions to ensure they had followed the story. Control questions had to be answered correctly for credit to be given for the test question. One point was awarded for a correct answer (blue, where Sally thinks it is) and a further point awarded for an appropriate justification, if the test question had been answered correctly, to give a maximum score of 2. Two independent coders scored 25% of children's responses. Agreement between the coders was excellent (Cohen's Kappa = .92). Scores were adjusted to account for the control questions and adjusted scores were used. ToM was defined as performance on the two tasks added together and therefore had a possible range of 0 to 5.

Reading comprehension

At Time 2, the York Assessment of Reading for Comprehension: Passage Reading (YARC; Snowling et al., 2011) was used to assess children's comprehension skills. The standardised test comprised of graded passages, alternating between fiction and non-fiction, for reading aloud by children aged five to 11 years. Children initially completed a single word reading task (Foster, 2007) to determine the starting passage level for the YARC. Children were then required to read two sequential passages from Form A (one fiction and one non-fiction). Following each passage, children were asked a set of eight comprehension questions tapping literal and inferential comprehension skills. Time 2 Reading Comprehension was therefore defined as the standard score, M = 100, SD = 15, on YARC passage reading. Across the stories suitable for this age group, the median Cronbach's Alpha is reported as .64.

Procedure

At both time points children were tested individually in a quiet area immediately outside of their classroom and administration of the test sessions was fully counterbalanced. Children were initially tested (Time 1) during the spring term in their nursery year. In Year 1, children were tested at the end of the summer term (Time 2). For both time points, testing sessions were part of a wider study investigating an extensive range of cognitive measures linked to early literacy development and, overall, children completed three to four 15 to 20 minute sessions at each time point.

Results

Descriptive statistics

Descriptive statistics for all variables are presented in Table 1. Distributions for variables were acceptable, with the exception of letter knowledge at Time 1, which was positively skewed. Data were log transformed to address the positive skew. The transformed variable was used in the analyses. There were no significant sex differences on any of the main variables, therefore gender was not considered in any further analyses.

Table 1: *Means and standard deviations for ToM and cognitive variables at T1and T2 (N = 80)*

Variable	Max	Mean (*SD*)	Range
T1 (Nursery, spring term)			
Non verbal ability			
Block design	19	12.09 (3.05)	4-18
Decoding			
Letter knowledge	26	7.15 (7.44)	0-25
Linguistic comprehension			
Receptive vocabulary (BPVS)	84	47.19 (10.27)	23-71
CELF recall sentence	52	34.37 (9.89)	2-52
CELF linguistic concepts	20	14.29 (4.00)	1-20
Executive function			
Reverse word span WM task	9	2.19 (2.53)	0-8
Card sorting task	9	5.43 (3.59)	0-9
Theory of mind			
First order false belief tasks	5	2.26 (1.90)	0-5
T2 (Year 1, end of year)			
Decoding			
Reading efficiency (TOWRE)	SS	123.56 (15.86)	90-154
Linguistic comprehension			
Receptive vocabulary (BPVS)	120	74.71 (11.64)	45-102
Narrative comprehension	29	18.01 (4.52)	9-27
Reading comprehension			
YARC	SS	108.03 (9.17)	81-125

Note: All raw scores unless otherwise noted; SS = standard scores; ToM = theory of mind; BPVS = British Picture Vocabulary Scale; CELF = Clinical Evaluation of Language Fundamentals; WM = working memory; TOWRE = Test of Word Reading Efficiency; YARC = York Assessment of Reading for Comprehension; T1 = Time 1; T2 = Time 2

Correlation analyses

Concurrent relations. Zero-order correlations are reported in Table 2. At Time 1, ToM significantly correlated with linguistic ability, decoding, and EF. T1 EF was significantly correlated with linguistic comprehension and decoding at T1. As expected from the SVR model, reading comprehension at T2 correlated with T2 linguistic comprehension and T2 decoding.

Longitudinal relations. In addition to concurrent relations, T2 reading comprehension was significantly correlated with T1 linguistic comprehension and T1 decoding. T2 reading comprehension was also significantly correlated with earlier T1 EF and T1 ToM. T1 ToM was strongly correlated with T2 linguistic comprehension; however, its relation with T2 word reading efficiency (decoding) was not significant.

Table 2: *Zero-order correlations between ToM and key composite measures at T1 and T2 (N = 80)*

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1. Age^{+}	-							
Nursery (T1)								
2. NVA	-.02	-						
3. Decoding	.09	.33**	-					
4. Linguistic comp	.48**	.38**	.44**	-				
5. EF	.32**	.14	.38**	.39**	-			
6. ToM	.21	.29**	.36**	.62**	.36**	-		
End Year 1 (T2)								
7. Decoding	-.13	.38**	.52**	.18	.11	.18	-	
8. Linguistic comp	.43**	.33**	.34**	.71**	.42**	.54**	.18	-
9. Reading comp	-.09	.36**	.50**	.36**	.22*	.44**	.54**	.43**

*Notes: * p < .05; **p < .01; T1 = Time 1; T2 = Time 2; $^{+}$ Age concurrent to time of assessment: 3:10 at T1 and 6:03 at T2; NVA = non-verbal ability; Linguistic. Comp = linguistic comprehension; EF = executive function; ToM = theory of mind; Decoding = letter knowledge at T1; word reading efficiency (words and non-words) at T2. Read comp = reading comprehension*

T1 ToM to T2 reading comprehension

To investigate the longitudinal relation between T1 ToM and T2 reading comprehension, a hierarchical regression analysis was performed to determine if the addition of an early measure of ToM improved the prediction of Year 1 (T2) reading comprehension beyond that accounted for by differences in age, NVA, the dimensions of the SVR (decoding and linguistic comprehension) and EF. To account for the effects of age, all variables (excluding NVA, reading comprehension and reading efficiency where age had been accounted for in standard scores) were residualized for concurrent age, thus becoming age-independent variables (Durand, Hulme, Larkin, & Snowling, 2005). Analysis was performed using SPSS REGRESSION and SPSS EXPLORE for evaluation of assumptions.

In the regression, NVA, and T1 decoding, language comprehension and EF skills were entered at Step 1 and T1 ToM measure was entered at Step 2. Following each step in the analysis, residuals and influence statistics were explored to check and address any violation of assumptions of normality. A significant skew was found in the distribution of standardized residuals and further investigation was conducted to identify one multivariate outlier. The regression was rerun with data from the remaining participants (*n* = 79).

Results of the analysis are reported in Table 3. Step 1 produced a significant model, $F(4, 74) = 9.32$, $p = < .001$ and an R^2 value of .34. Examination of the coefficients showed that T1 decoding skill (letter knowledge) uniquely predicted significant variance in reading comprehension at the end of Year 1 (T2). T1 NVA, linguistic comprehension and EF did not make a significant unique contribution to T2 reading comprehension. With the addition of T1 ToM at Step 2, an improved model was constructed, $F(5, 73) = 10.39$, $p < .001$, accounting for a further 8% of variance in T2 reading comprehension.

Table 3: *Hierarchical models: ToM at T1 predicting T2 reading comprehension controlling for SVR dimensions (decoding and linguistic comprehension), NVA and EF*

Variable	ΔR^2	*B (SE B)*	ß	*p*
Time 1 predictors of Year 1 (T2) reading comprehension (*N* = 79)				
Step 1	.34*			
NVA		0.56 (.32)	.19	.082
T1 Decode		3.28 (.99)	.37	.001*
T1 Linguistic comp		1.43 (1.04)	.16	.172
T1 EF		0.16 (.92)	.02	.863
Step 2	.08*			
NVA		0.56 (.30)	.19	.062
T1 Decode		3.14 (.94)	.35	.001*
T1 Linguistic comp		0.50 (1.15)	.06	.664
T1 EF		0.39 (.88)	.04	.656
T1 ToM (False belief)		3.32 (1.05)	.38	.003*
Total R^2 = .42*; $F(5, 73) = 10.39$, $p < .001$				

*Notes: T1 = Time 1; T2 = Time 2; NVA = non-verbal ability; Decode = letter knowledge (T1) and word reading efficiency (words and non-words) at T2; Linguistic comp = linguistic comprehension; EF = executive function EF; ToM = theory of mind; reading comprehension and NVA use standard scores all other variables are age residualized. * p < .01*

Is the link between early T1 ToM and later T2 reading comprehension direct or indirect?

A mediation analysis was conducted to investigate whether the relation between early ToM and later reading comprehension was *direct* over and above the dimensions of the SVR or *indirect* via the language dimension concurrent to the measure of reading comprehension. The analysis was performed by Hayes's PROCESS in SPSS (Hayes, 2012) using 1000 bootstrap samples to compute bias corrected and accelerated (BCa) confidence intervals (CI) around the indirect effect. Significant indirect effects are indicated when the confidence interval does not include zero (Preacher & Hayes, 2008; see Field, 2013).

In the analysis, ToM was modeled as a predictor of T2 reading comprehension, mediated by T2 linguistic comprehension (Kim, 2015). T1 variables (NVA, EF, linguistic comprehension and decoding ability) were controlled for. Results are shown in Figure 1.

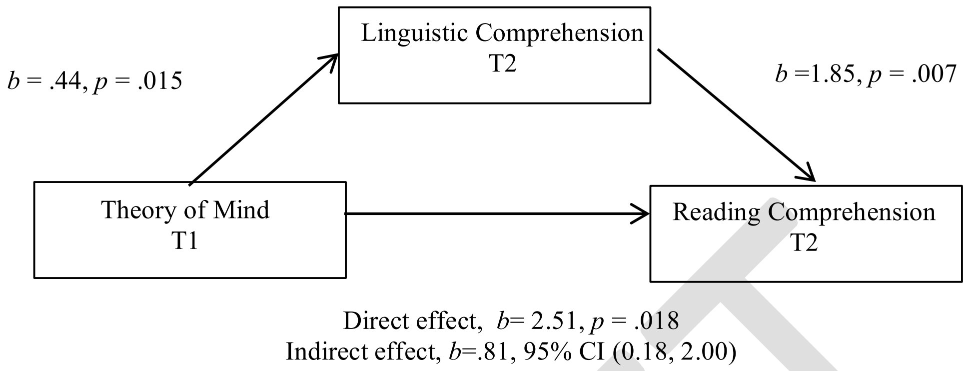

Figure 1: Mediation analysis showing both a direct effect of Time 1 (T1) ToM on Time 2 (T2) reading comprehension and an indirect effect via T2 linguistic comprehension. Age, non verbal ability, executive function, language and decoding at T1 were controlled in the analysis. Unstandardized estimates presented with significance based on absence of zero in bootstrapped confidence intervals; confidence interval for each indirect effect is a BCa bootstrapped CI based on 1000 samples.

At T1 (Figure 1), there was a significant indirect effect of T1 ToM on later T2 reading comprehension through T2 linguistic comprehension, *b* = .81, BCa CI (0.18, 2.00), as indicated by the 95% CI. There was also a significant direct effect of T1 ToM on later T2 reading comprehension, *b* = 2.51, *p* = .018.

Discussion

The aim of the current study, spanning a two and a half year period, was to investigate the relation between children's early ToM ability at around four years old and their later emergent reading comprehension at six years old, over and above the effects of the dimensions of the SVR (decoding and linguistic comprehension). The influence of age, non-verbal ability (NVA) and executive function (EF) skills, measured at around four years, was also controlled within the analyses. We were specifically interested whether this effect was direct or indirect via linguistic comprehension concurrent with later reading comprehension.

Does ToM predict ability in reading comprehension?

Regression analyses showed that earlier ToM, at Time 1 (mean age 3:10) uniquely contributed to later reading comprehension ability at six years, even after controlling for age, measures of NVA, EF and the two dimensions of the SVR (decoding and linguistic comprehension). In sum, *early* ToM, measured as false belief understanding uniquely predicted later reading comprehension.

Is the relation between ToM and reading comprehension direct or indirect via linguistic ability?

Results from the mediation analyses showed a significant indirect effect from ToM at Time 1, to Time 2 reading comprehension via Time 2 linguistic comprehension, suggesting that children's developing ToM also facilitated the language skills that are crucial for successful reading comprehension. These findings provide further evidence of the predictive relation between children's ToM ability and language development (Hughes, Ensor, & Marks, 2010; Milligan et al., 2007; Slade & Ruffman, 2005). Additionally, they replicate a recent cross-sectional study with six-year-old children that showed an indirect pathway from ToM to concurrent reading comprehension, via language comprehension (Kim, 2015). Importantly, our novel findings extend this effect across a crucial early developmental period. Children typically begin to pass false belief tasks between the ages of three and five years old (Wellman et al., 2001). In other words, we showed that children's developing social cognition across the early years affects their later emerging reading comprehension through the facilitation of language skills. This explanation fits within the SVR account of reading comprehension (Gough & Tunmer, 1986; Hoover & Gough, 1990), such that ToM contributes to the linguistic dimension of the framework.

However, importantly, our mediation analysis also showed that a significant *direct* relation remained between early ToM and later reading comprehension, over and above the linguistic comprehension dimension of the SVR. This is the first longitudinal study to show a direct contribution of theory of mind to reading comprehension. Preschool ToM at Time 1 predicted abilities specific to reading comprehension that go beyond skills required to comprehend spoken language. This novel finding is an important contribution to the understanding of the development of reading comprehension and indicates that the direct effect of early ToM to later reading comprehension may be as a result of *when* children gain a ToM. At six years old, during this early stage of reading comprehension acquisition, decoding ability is the strongest predictor of reading comprehension leaving less to be explained by linguistic skills and, typically, the balance shifts with development, such that linguistic comprehension becomes more fundamental once word reading is fluent and efficient (Adlof, Catts, & Lee, 2010; Ouelette & Beers, 2010; Vellutino et al., 2007). It is plausible that previous studies (Guajardo & Cartwright, 2016; Kim, 2015), investigating the influence of ToM of older children, or with small samples with a broad age range, may have missed these early potentially crucial developmental effects. Additionally, the non-standard and linguistically-demanding ToM tasks employed in previous studies may have masked the effects of ToM or been biased to general language ability. Indeed, our finding is consistent with previous research suggesting that *early* ToM directly relates to later cognitive performance (Lecce et al., 2014; Lecce et al., 2011; Lockl & Schneider, 2007).

Why does early theory of mind directly predict later reading comprehension?

False belief understanding marks a crucial step in meta-cognitive development (e.g., Bartsch & Estes, 1996; Flavell et al, 2000). This may be because it is part of, or draws upon, domain general meta-cognitive abilities (Iao et al., 2011; Perner, 1991; Perner et al., 2002) or because it is a socially specialized ability (e.g., He, Bolz & Baillargeon, 2011) that facilitates other aspects of meta-cognition e.g., meta-memory (Lecce et al 2014; Lockl & Schneider, 2007) or source monitoring (Bright-Paul et al, 2008). Nevertheless, we argue that it is the coming online of these abilities that is crucial and that false belief understanding reflects a “watershed” in their availability. The early acquisition of theory of mind allows children greater exposure to and opportunities to use metacognitive strategies that facilitate later development of higher order comprehension skills (e.g., self monitoring and repair strategies), which promote increased performance in reading comprehension (Oakhill & Cain, 2012; Perfetti, Landi, & Oakhill, 2005). In other words, gaining false belief understanding early provides children with longer exposure to and, therefore, more opportunities and experience in using metacognitive skills relevant for reading comprehension, i.e., comprehension monitoring (Kirby & Savage, 2008) and meta-linguistic understanding (Yuill, 2009). Consistent with this, Lockl and Schneider (2007) concluded from their study that those children acquiring an *early* ToM performed better in the later meta-memory tasks, suggesting that gaining a ToM might be a crucial step in metacognitive development.

ToM and the SVR account of reading comprehension

Overall, our findings show a robust effect where ToM is indirectly linked to reading comprehension via linguistic comprehension, such that the effects of ToM are accounted for within the SVR framework via one of its key dimensions. Children's social cognition facilitates linguistic comprehension, which may play an important role in reading. Importantly though, early ToM also directly contributed to reading comprehension over and above the dimensions of the SVR. As we have argued, this is likely to be because it marks a watershed in metacognitive abilities relevant to reading comprehension. These metacognitive abilities will clearly be relevant to making sense of stories, thoughts and actions, specifically including socially relevant abilities such as thinking about characters' thoughts and feelings and linking those to actions within stories. Crucially, however, it will also be relevant to other broader metacognitive abilities relevant to reading, such as meta-memory (Lecce et al., 2014) and comprehension monitoring (Kirby & Savage, 2008).

As a result of their study, Ricketts et al. (2013) suggest that the SVR framework should be extended to include mental state understanding when accounting for reading comprehension in an Autistic Spectrum Disorder population. These claims for ToM, indicating a role for meta-cognition, are consistent with the theory that higher-order comprehension processes, such as inference making, are used to integrate information from the text with the reader's general knowledge to the create a mental model of the text or situation model (Kintsch & Rawson, 2005; Perfetti & Stafura, 2014). The results from the current study support the view that ToM is a significant predictor of reading comprehension in *typically developing children*, and therefore should be included in the SVR model. An account of metacognition is essential to provide a full explanation of reading comprehension (Kirby & Savage, 2008) and the SVR may need to be expanded to account for metacognitive skills, particularly for the acquisition and early development of reading comprehension.

Limitations

One of the main strengths of the current longitudinal study was initially assessing pre-readers before the beginning of formal literacy instruction. However, research with very young children brings inherent problems with regard to finding reliable measures. To limit demands on the children, assessment sessions were restricted in number and length; therefore, some variables were measured at a single time. However, during these early years, children's development may be uneven and episodic and highly influenced by their environment, therefore it may have been more reliable to measure children's abilities within each construct through a variety of assessments over different days. Overall, however, our sample performed highly in the standardized assessment tasks and were from families who reported above-average educational levels. As such, this may potentially limit the degree to which our results are extended to the population in general.

The current study did not include additional measures of metacognition. Future research in this field should address this issue with the assessment of other aspects of metacognitive ability (for example, measures of source monitoring; Bright-Paul et al., 2008) at each time point. Additionally, six years is a relatively young age to assess reading comprehension. Decoding ability is the strongest predictor of reading comprehension through this early stage, but as word reading becomes more fluent and efficient, linguistic comprehension develops greater significance. Follow up assessments are vital to investigate how metacognitive ability relates to reading comprehension as the balance shifts between decoding and linguistic abilities.

Conclusion and Implications

In conclusion, this longitudinal study provides robust evidence that theory of mind through the early years promoted later linguistic comprehension, which in turn contributed to reading comprehension. Importantly, we also show a novel finding that ToM directly contributed to performance of reading comprehension, over and above age, NVA, decoding and linguistic comprehension and EF, in a typically developing population. This is the first longitudinal study to show that gaining *early* ToM (measured by false belief understanding) predicts better reading comprehension ability, two and a half years later. The current study supports previous research that has argued that early ToM leads to better performance in later academic achievement (Lecce et al., 2011) and cognitive development (Lecce et al., 2014; Lockl & Schneider, 2007). Specifically, we show that early ability predicts later reading comprehension performance. Children may benefit from early ToM because it allows earlier and greater experience of applying metacognitive strategies, which become crucial for later reading comprehension.

These findings have important applied implications. Robust relations between linguistic ability and EF for both ToM (Milligan et al., 2007; Devine & Hughes, 2014) and reading comprehension (Cain et al., 2004; Kendeou et al., 2009; Paris & Paris, 2003; Sesma et al., 2009) have been well established. As a result, instruction and training in these skills are being increasingly promoted through the early years of education (e.g., Diamond, Barnett, Thomas, & Munro, 2007). The predictive link between ToM and reading comprehension, over and above the effects of language and EF, suggests that ToM is a crucial component in the development of reading comprehension. Likewise, parent and child discussion during shared reading may be an important context to learn about ToM and reading comprehension more generally (Symons, 2004; Symons, Peterson, Slaughter, Roche, & Doyle, 2005). Therefore, instruction and training in the skills and knowledge that underlie false belief understanding (e.g., Lecce et al., 2014) would be beneficial as an additional approach in promoting emerging reading comprehension.

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